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CAUTIONARY TALES FOR REDUCED-GRAVITY PARTICLE RESEARCH

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Particle experiments conducted by the present investigators on the KC-135 aircraft in zero gravity could be described as having been "less than successful". While such phrasing may be appropriate for scientific journals, the freedom of speech afforded by this abstract enables a more honest appraisal. We report here on tests that were a "total failure". We discuss why this failure occurred, and the sort of questions that potential researchers should ask in order to avoid the appearance of abstracts such as this. Many types of aggregation studies have been proposed for Space Station, and it is hoped that the following synopsis of events will add a touch of reality to experimentation proposed for this zero-gravity environment.

First, however, a word on the motivation for the experiments. Impact cratering, volcanism, and aeolian activity on planetary surfaces inject large quantities of finely-comminuted material into planetary atmospheres. Geological events subsequent to this injection are partially dependent on the degree to which the material aggregates owing to electrostatic and other interparticle forces. Since the material (in the case of impact and volcanism) is freshly comminuted, it should be highly charged electrostatically, and a large measure of aggregation would be expected. However, very little is known about the rate at which this might occur, the level of dust concentration necessary to initiate and sustain significant aggregation rates, how large aggregates may grow, whether or not the aggregation process is selective for certain materials, and whether the structures have sufficient strength to survive their descent to a planetary surface. The answers to these questions would enable conclusions to be drawn about the atmospheric cleansing rate (applicable to such broad concerns as climatic change and nuclear fall-out), the distribution of volcanic ash and aeolian loess, the potential hazards of volcanic surges and pyroclastic flows, the redistribution of wind-blown soils in agricultural areas, and so on.

If aggregation is to be studied for planets that have surface gravitation less than 1g, or if terrestrial cases require prolonged suspension of the aggregates under study, it is essential to investigate the possibility of zero, or reduced, gravity testing. Only under such circumstances can aggregates be prevented from falling to the floor of the experimental apparatus before their behavior has been documented. As a precursor to potential Space Station activities, we conducted aggregation studies both on the ground, and in the KC-135, zero-g aircraft.

Ground experiments consisted of injecting dust into a sealed box with compressed gas. The first discovery was that low concentrations of dust did not show any apparent signs of aggregation, despite the highly charged nature of the dust. Success was achieved however, with high concentrations. Unfortunately, high concentrations do not permit visibility into the central region of interest -- observation becomes limited to the edges of the box where wall-effects are prevalent. Our second discovery concerned the cause of aggregation -- it transpired that particles were more prone to aggregate in the presence of an operator! This was due to the electrostatic field of the human body, and not a result of cooperative materials. There was a marked propensity for aggregation on the walls of the box, and this could not be avoided (these were the largest, and sometimes, the only aggregates). The particles (of basalt dust) were wholly indiscriminate in their choice of surface -- attraction occurred to plastic, glass, wood, paper, rubber, copper, steel, and a host of other materials even after treatment with antistatic spray. An aggregate experiment cannot be conducted scientifically unless wall effects are eliminated, and it must be borne in mind that a Space Station container will be small compared to the electrostatic "reach" of the walls.

Undaunted, we proceeded to conduct experiments on the KC-135 in zero gravity, but to avoid the pitfalls of our ground experiments, only large (1-2mm) particles of charged quartz were used. This would enable visibility through the material, and the wall effects would be less. The particles were injected into the experimental chamber with an air jet, or allowed to fall into the chamber during reduced gravity. This experiment will not work on an aircraft such as the KC-135 if it is anchored, because the zero-gravity parabola is insufficiently stable to retain particles in the center of such a small system. After observing particles on every wall, but not in the center of the box, we concluded that a free-floating experiment would be our only hope (yet to be attempted). Even with relatively stable flying, the experiment failed because it was extremely difficult to <u>disaggregate</u> the particles which perambulated in a clump from one location to another. The air jet did no more than shift the clump from one place to another, as did gentle (and sometimes less than gentle) tapping on the side of the experimental chamber. Aggregation cannot be studied unless the particles are initially dispersed without a great deal of relative motion between the grains. This problem is far from trivial, but it has received very litle attention in Space Station considerations.

We suggest the following for potential investigators of particles in zero gravity: 1) Conduct very extensive investigation of the types of chamber material that will <u>not</u> attract particles. Whatever the chamber is made of, however, the viewing port will probably be glass -- which attracts particles, 2) Determine if the concentrations required for aggregation within the time frame set by 10^{-5}g will allow visibility into the chamber, 3) Find ways of disposing of the test material -- this was found to be a very messy process in zero-g, 4) Determine how surfaces will be cleaned ready for the next investigator. There are materials on the market that can be coated as a liquid (with a brush) onto solid surfaces, and after a few minutes, the material sets as a film that can be peeled away leaving a totally clean surface (developed for the semiconductor industry), 5) Determine how the material will be dispersed initially -- this is absolutely crucial -- any variation in relative velocities will give variation in collision potential, and hence variation in aggregation rates, 6) Be sure that the experiment does not have electrostatic, radiation pressure, or other forces acting spuriously on the material. Is the experiment next to you producing powerful force fields ? Will the astronaut cause aggregation or dispersion when he peers into the chamber ? Does the Space Station laboratory module have its own electrostatic field ? Unless these questions are seriously addressed, a great deal of time and recources could result in one outcome -- an abstract similar to this one.